

TITLE OF THE INVENTION

DIGITAL BROADCASTING TRANSMISSION/RECEPTION SYSTEM CAPABLE OF
IMPROVING RECEIVING AND EQUALIZING PERFORMANCE AND SIGNAL PROCESSING
METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of PCT International Patent Application No. PCT/KR 2005/001940 filed June 23, 2005, and Korean Patent Application No. 2004-47153 filed June 23, 2004 in the Korean Intellectual Property Office, the disclosures of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] An aspect of the present invention relates to a digital broadcasting transmission/reception system, and more specifically, to a digital broadcasting transmission/reception system generating stuff byte in a Moving Picture Experts Group-2 transport stream (MPEG-2 TS), and operating and transmitting a pattern of known data using the stuff byte to improve reception performance and equalization performance of a reception system and a signal processing method thereof.

2. Description of the Related Art

[0003] The Advanced Television Systems Committee Vestigial Sideband (ATSC VSB) method, a U.S.-oriented terrestrial waves digital broadcasting system, is a single carrier method that uses a field sync by 312 segment unit. Accordingly, reception performance is not good in poor channels, especially in a Doppler fading channel.

[0004] Fig. 1 is a block diagram of a transmitter/receiver of a general U.S.-oriented terrestrial waves digital broadcasting system according to the ATSC digital television (DTV) standards.

[0005] The digital broadcasting transmitter of Fig. 1 has a data randomizer (110) for randomizing an MPEG-2 TS, an Reed-Solomon (RS) encoder (120) of a concatenated coder form for correcting errors generated by channels, an interleaver (130), and a 2/3 rate trellis encoder (140). The encoded data is mapped in 8 level symbols and field syncs and segment syncs are inserted into the data as shown in Fig. 2. After that, pilots are inserted into the data, the data is VSB-modulated, upconverted into RF and transmitted.

[0006] Meanwhile, the digital broadcasting receiver of Fig. 1 lowers the RF signal to baseband, demodulates and equalizes the lowered signal, performs channel decoding, and restores the original signal in a reverse order of the digital broadcasting transmitter. Fig. 2 shows a vestigial sideband (VSB) data frame of the U.S.-oriented DTV system. In Fig. 2, one frame consists of two fields. One of the fields includes the 312 data segments and the field sync segment. One segment has segment syncs of four symbols and data symbols of 828 symbols.

[0007] As shown in Fig. 1, the digital broadcasting transmitter randomizes the MPEG-2 TS through the randomizer (110). The randomized data is outer-coded through the RS encoder (120) which is an outer coder, and the outer-coded data is dispersed through the interleaver (130). The interleaved data is inner-coded by 12 symbol unit through the trellis encoder (140), and the inner-coded data is mapped in an 8 level symbol and inserted with the field syncs and segment syncs as shown in Fig. 2. Thereafter, the data includes DC offset to generate the pilot, and the data is VSB-modulated, upconverted to an RF signal and transmitted.

[0008] Meanwhile, the digital broadcasting receiver of Fig. 1 converts an RF signal received through a channel into a baseband signal through a tuner/IF (not shown). The baseband signal is synchronization-detected and demodulated through a demodulator (210), and any distortion by multi-path channel is compensated through an equalizer (220). The equalized signal is error-corrected and decoded into symbol data through a viterbi decoder (230). The decoded data, which has been dispersed by the interleaver (130) of the transmitter, is rearranged through a de-interleaver (240), and the deinterleaved data is error-corrected through an RS decoder (250). The error-corrected data is de-randomized through a derandomizer (260) and output into an MPEG-2 TS.

[0009] In the VSB data frame of the US-oriented terrestrial waves DTV system of Fig. 2, one segment corresponds to one MPEG-2 packet. In Fig. 2, the segment sync and field sync, which

are sync signals, are used for synchronization and equalization. The field sync and segment sync are known sequences and used as training data in the equalizer.

[0010] The VSB method of the U.S.-oriented terrestrial waves digital television system of Fig. 1 is a single carrier system and has the capacity to remove multipath in a multipath fading channel with Doppler. However, if the known sequence such as a field sync is used a lot, it becomes easier to estimate the channel and compensate the signal distorted by multipath in the equalizer using the known sequence.

[0011] However, as shown in the VSB data frame of the U.S.-oriented terrestrial waves digital television system of Fig. 2, a field sync which is a known sequence appears in every 313th segment. This is not frequent so the capacity to remove the multipath and equalize the received signal using this, is low.

SUMMARY OF THE INVENTION

[0012] An aspect of the present invention is to provide a digital broadcasting transmission/reception system to improve reception performance and equalization performance of a reception system by adding a predefined known sequence, manipulating a pattern and transmitting a signal in a transmission system and a signal processing method, and a digital broadcasting reception system corresponding to the above and a signal processing method thereof.

[0013] A digital broadcasting system including a digital broadcasting transmitter encoding a data stream including stuff bytes at a certain location, modulating, RC-converting and transmitting the encoded data stream; and a digital broadcasting receiver receiving the encoded data stream, demodulating the encoded data stream into a baseband signal, detecting the known data from the demodulated signal, and equalizing the demodulated signal using the detected known data.

[0014] According to another aspect of the present invention, there is provided a signal processing method of a digital broadcasting system includes encoding a data stream including stuff bytes at a certain location, modulating, RC-converting and transmitting the encoded data

stream; and receiving the encoded data stream, demodulating the encoded data stream into a baseband signal, detecting the known data from the demodulated signal, and equalizing the demodulated signal using the detected known data.

[0015] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

Fig. 1 is a block diagram illustrating a transmitter of a general U.S.-oriented terrestrial digital broadcasting system;

Fig. 2 is a view of a frame structure of ATSC VSB data;

Fig. 3 is a view of a frame structure of a TS packet;

Fig. 4 is a view of a frame structure of a TS packet including a stuff byte;

Fig. 5 is a block diagram of a digital broadcasting transmission/reception system according to an embodiment of the present invention;

Fig. 6 is a view of a format of the data input to the randomizer of Fig. 5;

Fig. 7 is a view of a format of the data output from the randomizer of Fig. 5;

Fig. 8 is a view of a format of the data output from the RS encoder of Fig. 5;

Fig. 9 is a view of a format of the data output from the data interleaver of Fig. 5;

Fig. 10 is a view of a format of the data output from the trellis encoder of Fig. 5;

Fig. 11 is a view of a format of the data output from an RS re-encoder according to trellis initialization of the known sequence section;

Fig. 12 is a block diagram illustrating a digital broadcasting transmission/reception system according to another embodiment of the present invention; and

Fig. 13 is a view illustrating the known symbol location detector/known data output of Fig. 5.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0017] Reference will now be made in detail to the present embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

[0018] Fig. 3 shows a frame structure of a TS packet and Fig. 4 shows a frame structure of a TS packet with a stuff byte. The TS packet of Fig. 3 includes an MPEG-2 header, and an adaptation field or ES data. According to an aspect of the present invention, stuff bytes are inserted in a packet as illustrated in Fig. 4 so that all the TS streams have adaptation fields.

[0019] That is, the MPEG-2 TS packet of Fig. 4 is an MPEG-2 packet of 188 bytes and consists of an MPEG-2 header, an adaptation field and ES or payload data. The header includes 4 bytes with MPEG syncs, the adaptation field includes an adaptation field length section of 1 byte indicating the length of the adaptation field, an adaptation field data section having other information of 1 byte and stuff bytes of N bytes, and the payload data includes ES data of $188-(4+2+n)$ bytes.

[0020] Fig. 5 is a block diagram illustrating a digital broadcasting transmission/reception system according to an embodiment of the present invention. In Fig. 5, the digital broadcasting transmitter receives an MPEG-2 packet TS having the packet structure of Fig. 4 through a TS multiplexer (not shown).

[0021] In Fig. 5, the digital broadcasting transmitter has a data randomizer (310) for randomizing the input TS stream, a stuff byte replacer (315) for replacing the stuff byte of the randomized data with a particular sequence, an RS encoder (320) constructing the data output from the stuff byte replacer (315) in the concatenated code form to correct errors generated by channels, an interleaver (330) for interleaving the data, a packet buffer (325) storing the RS-encoded reference data to initialize a memory of a trellis encoder (340) and replacing the previous value with an initialized value, an RS re-encoder & replace parity (335) performing RS-encoding using the altered value, generating a parity and inputting the parity to the trellis encoder (340), the trellis encoder (340) converting the interleaved data into symbols and performing 2/3 rate trellis encoding and 8 level symbol mapping, a multiplexer (350) inserting

field syncs and segment syncs as shown in Fig. 2, a transmission part (360) for inserting a pilot, performing VSB-modulation, upconverting the data into RF and transmitting the data, and a control signal generator (370) for generating a signal to control data processing.

[0022] In Fig. 5, the digital broadcasting receiver goes through a reverse order of the transmitter and the receiver includes a demodulator (410) lowering the RF signal to baseband and demodulating the signal, an equalizer (420) removing inter-symbol interference, a Viterbi decoder (430) for performing error-correction and decoding, a de-interleaver (440), an RS decoder (450), and a de-randomizer (460). Additionally, the receiver further includes a known symbol location detector/known symbol output (470) detecting and outputting the location of the known symbol from the demodulated data.

[0023] Further, Fig. 13 is a block diagram illustrating the known symbol location detector/known symbol output (470) in detail, and the known symbol location detector/known symbol output (470) includes a known symbol number detector (471), a segment flag generator (473), a trellis interleaver (475) and a known data extractor (477).

[0024] In the digital broadcasting transmitter, if the information of the number of stuff bytes is inserted in the reserved part of the field sync data segment section, the known symbol number detector (471) of the known symbol location detector/known symbol output (470) of the receiver detects the information of the number of the known data, the segment flag generator (473) and trellis interleaver (475) find the information of the location of the known symbol based on the detected information, the known data extractor (477) outputs the known data according to the acquired information on the location, and the known data is used to improve reception performance of the receiver. If the information of the number of the stuff bytes is acquired, as the location of stuff bytes is always fixed, the segment flag generator (473) and trellis interleaver (475) can be implemented using a counter and control logic.

[0025] Meanwhile, an MPEG-2 packet TS having the packet structure of Fig. 4 is input to the randomizer (310) through the TS multiplexer (not shown), randomized, replaced with a particular sequence for the stuff bytes by the stuff byte replacer (315) and output. The output data is outer-coded through the RS encoder (320) to correct errors by channels and the outer-coded data is dispersed through the interleaver (330).

[0026] Subsequently, the interleaved data is inner-coded by a 12 symbol unit through the trellis encoder (340). The inner-coded data is mapped in 8 level symbols and the field syncs and segment syncs are inserted as shown in Fig. 10 by the multiplexer (350). Thereafter, the data includes a DC offset to generate a pilot and the data is VSB-modulated, up-converted into RF and transmitted.

[0027] Meanwhile, the control signal generator (370) detects the adaptation field length of Fig. 4, and generates and outputs a flag signal to indicate the location of stuff bytes or known sequence data based on the detected result.

[0028] Further, in Fig. 5, the trellis encoder (340) performs initialization of 12 trellis encoder at the beginning location of the known sequence, for example, in order for the value of the memory element of the encoder to become '00'. The sequence altered by the initialization replaces the value stored in the packet buffer (325) and the new parity generated by the RS re-encoder & replace parity (250) replaces the value of the original parity location input to the trellis encoder (340) so that the initialization is performed.

[0029] Fig. 6 to Fig. 10 show data formats while an MPEG-2 packet with stuff bytes passes through channel encoder blocks of the digital broadcasting transmitter.

[0030] Fig. 6 shows a format of the data input to the randomizer (310) and Fig. 7 shows a data format after replacing n stuff bytes of the randomized data with particular sequence data. Fig. 8 shows a data format of the RS-encoded data added with RS parity and Fig. 9 shows a data format of the data output from the interleaver (330).

[0031] Further, Fig. 10 shows a format of the 12 symbol interleaved data output from the trellis encoder (340). Fig. 11 is a format of the data whose parity is restructured by the RS re-encoder & replace parity (335) of Fig. 3. In Fig. 10, one field includes six convolutional interleavers, so there are six sequences with stuff bytes. That is, if a TS includes stuff bytes of 10 bytes, one field has known sequences of $10 \times 6 = 60$. If the trellis encoder (340) is initialized at the beginning location of the known sequence, the output parity of the RS encoder (320) is altered by the value of initialization and trellis encoding is performed by updating with the altered parity.

[0032] The MPEG-2 packet of Fig. 6 is dispersed by 52 units by the interleaver (330) as shown in Fig. 9. The data located in the same byte of the MPEG-2 packet constructs the same column as shown in Fig. 9 after data interleaving. Additionally, the interleaved data are 12-symbol-interleaved by the trellis encoder (230) as shown in Fig. 10. That is, the data of the same location in MPEG-2 packets construct almost one data segment as shown in Fig. 10 after trellis encoding. Therefore, if a particular part of an MPEG-2 packet is continuously added with stuff bytes, randomized, replaced with a particular sequence and trellis-encoded, the stuff bytes form one data segment which is a known signal and a digital broadcasting receiver uses the known signal to improve reception performance.

[0033] Fig. 11 shows a data format after RS re-encoding and parity restructuring by the RS re-encoder & replace parity (335) of Fig. 5. That is, if the trellis encoder (340) is initialized at the beginning location of a sequence of the known symbol, output parity of the RS encoder (320) is altered by the value of the initialization and trellis encoding is performed by being updated with the altered parity so that there is no problem in decoding of the RS decoder of a digital broadcasting receiver which will be described below. That is, the trellis encoder is initialized in order for the trellis-encoded data to form a regular sequence during the known symbol sequence section, RS encoding is performed to replace the data of the initialization location so that parity is altered and the altered parity replaces the original parity. Fig. 11 shows the data format.

[0034] Meanwhile, the demodulator (410) of a digital broadcasting receiver downconverts the RF signal received through a channel into a baseband signal through a tuner/IF (not shown), and the converted baseband signal is sync-detected and demodulated. The equalizer (420) compensates channel distortion by multipath of channels in the demodulated signal.

[0035] Meanwhile, a known symbol location detector/known data output (470) detects information on the number of stuff bytes inserted in the reserved section of field sync data segment section, acquires information on the location of the known symbol and outputs the known data from the acquired information on the location.

[0036] In a digital broadcasting transmitter, if the information on the number of stuff bytes is inserted in a reserved section of a field sync data segment section, a known symbol number detector (471) of a known symbol location detector/known data output (470) of the digital

broadcasting receiver detects the information on the number of the known data, a segment flag generator (473) and trellis interleaver (475) find the location information of the known symbol based on the information, and a known data extractor (477) outputs and uses the known data from the acquired information to improve reception performance of the digital broadcasting receiver. As the location of stuff bytes is always fixed, if the information on the number of the stuff bytes is acquired, the segment flag generator (473) and trellis interleaver (475) can be implemented using a counter and control logic.

[0037] Meanwhile, the equalized signal by the equalizer (420) is error-corrected through the Viterbi decoder (430) and decoded in symbol data. The decoded data rearranges the data dispersed by the interleaver (330) of the digital broadcasting transmitter through the deinterleaver (440). The deinterleaved data is error-corrected through the RS decoder (450). The error-corrected data is derandomized through the derandomizer (460).

[0038] Fig. 12 is a block diagram illustrating a digital broadcasting transmission/reception system according to another embodiment of the present invention. In Fig. 12, the digital broadcasting transmitter has a randomizer (510) for randomizing data of the input TS stream, a stuff byte replacer (515) for replacing the stuff byte of the randomized data with a particular sequence generated in a replacement sequence generator (513), an RS encoder for constructing the data output from the stuff byte replacer (515) in the concatenated code to correct errors generated by channels, an interleaver (530) for interleaving the data, a packet buffer (525) for storing the RS-encoded reference data to initialize a memory of the trellis encoder (540) and replacing the stuff byte with an initialized value, an RS re-encoder & replace parity (535) for performing RS-encoding using the altered value to generate parity and inputting the data to the trellis encoder (540), the trellis encoder (540) for converting the interleaved data into a symbol and performing 2/3 trellis encoding and 8 level symbol mapping, a multiplexer (550) for inserting a field sync and segment sync as in the data format of Fig. 2, a transmission part (560) for inserting a pilot, performing VSB-modulation, converting the data into RF and transmitting the data, and a control signal generator (570) for generating a signal to control data processing.

[0039] In Fig. 12, the digital broadcasting receiver follows a reverse order of the transmitter and includes a demodulator (610) for lowering the RF signal to baseband and demodulating it,

an equalizer (620) for deleting inter-symbol interference, a Viterbi decoder (630) for error-correcting and decoding, a deinterleaver (640), an RS decoder (650), and a derandomizer (660). Additionally, the receiver further includes a known symbol location detector/output (670) for detecting and outputting the location of the known symbol from the demodulated data.

[0040] The function and operation of each component of the digital broadcasting transmission/reception system of Fig. 12 is similar to the components of Fig. 5. Therefore, a detailed description of the function and operation is omitted and the difference will be described.

[0041] A stuff byte replacer (515) replaces stuff bytes of the data randomized by the randomizer (510) with a particular sequence and outputs the data. In this case, a pattern of the particular sequence may be preferably adjusted in order for the symbols mapped through the trellis encoder (540) to be well operated by the equalizer (620).

[0042] Therefore, according to another embodiment of the present invention, the digital broadcasting transmitter further includes the replacement sequence generator (513) for generating a particular sequence to replace the stuff bytes and providing the particular sequence to the stuff byte replacer (515) in order for the pattern of the known sequence generated by replacing the stuff bytes to well operate the equalizer (620).

[0043] According to another embodiment of the present invention the replacement sequence generator (513), and a parity reconstruction (535) of the transmitter and a known data detector (670) of the receiver operate differently from the digital broadcasting transmission/reception system of Fig. 5.

[0044] The replacement sequence generator (513) includes a memory (not shown) for storing the particular sequence to replace the stuff bytes in the stuff byte replacer (515) and a circuit (not shown) for controlling a memory address.

[0045] If the sequence pattern of the known data of Fig. 9 and Fig. 10 has a random pattern without DC offset, operation performance of the equalizer can be improved. Accordingly, the replacement sequence generator (513) may preferably generate a particular sequence to replace the stuff bytes so that the sequence pattern of the known data mapped after trellis encoding of the trellis encoder (540) in the stuff byte replacer (515) has the random pattern

without DC offset.

[0046] First, in order for the sequence of the known data to have a desirable pattern, the memory value of the trellis encoder (540) has to be initialized.

[0047] The compatibility is maintained with the existing receiver and the memory value of the trellis encoder (340) is initialized by the packet buffer (325) and RS re-encoder & replace parity (335) of Fig. 5. According to a method of an embodiment of the present invention, the method initializes the memory value of the trellis encoder (340) of part of the stuff bytes according to the number of stuff bytes instead of the entire stuff bytes in order to be compatible with the existing receiver. Accordingly, the initialized stuff bytes can limitedly have a desirable pattern.

[0048] Therefore, in another embodiment of the present invention, the function of initializing a memory value of the trellis encoder (540) for the entire stuff bytes, is added to the RS re-encoder & replace parity (535). That is, the RS re-encoder & replace parity (535) is compatible with the existing receiver and initializes the memory value of the trellis encoder (540), according to an embodiment of the present invention, depending on initial set-up and user choice, and ignores the compatibility with the existing receiver and initializes the memory value of the trellis encoder (540) for the entire stuff bytes.

[0049] In addition, the known symbol location detector/known data output (670) of the receiver is added with the function corresponding to the added function of the parity reconstruction (535) of the transmitter.

[0050] The value of the part that initializes the memory value of the trellis encoder of the particular sequence, which is generated in the replacement sequence generator (513) and replaces the stuff bytes in the stuff byte replacer (515), can be any value. The replacement sequence generator (513) considers the symbol value, mapped after trellis-encoding according to the memory value to have the desired pattern by the sequence of the known data wants after the initialization, and generates the particular sequence to replace the stuff bytes.

[0051] The replacement sequence generator (513) stores the above particular sequence in the memory (now shown) and is controlled to adjust the sync by a control signal generator (570). Accordingly, the sequence of the known data improves the operation performance of the

equalizer and the receiver.

[0052] As above-described, stuff bytes are generated and inserted in an MPEG-2 TS packet, the inserted stuff bytes are transmitted as known data from the digital broadcasting transmitter and the digital broadcasting receiver detects and uses the known data so that reception performance such as sync acquisition and equalization performance can be improved.

[0053] In addition, the sequence of the known data improves the operation performance of the equalizer so that the reception performance of the receiver can also be improved.

[0054] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.